

Organic Compounds in INTEC Tank Farm Waste

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September 2005

**Idaho
Cleanup
Project**

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Idaho Falls, Idaho 83415

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ABSTRACT

Approximately 830,000 gallons of liquid, radioactive, sodium-bearing waste (SBW) are currently stored in three 300,000-gallon tanks at the Idaho Nuclear Technology and Engineering Center Tank Farm. Designing and permitting a SBW treatment facility requires characterization of the waste. This report documents the organic content of the current Tank Farm waste. The wastes remaining in the three tanks are the same waste type (SBW), have similar chemical composition, have undergone similar treatment (evaporation), and were derived from the same or similar sources. Wastes from two of the three tanks have been characterized for organics. The measured organic content of the waste is low, less than 1 g/l of total organic carbon and generally no detectable, specific volatile or semi-volatile compounds.

Although the contents of one tank have not been characterized for organics, the organic content of the wastes in all three tanks is similar due to the similarity in the sources and treatment of the wastes. The organic content of the wastes that have been analyzed, along with that of historical wastes, is characteristic of the waste in the tank that has not been analyzed.

SUMMARY

Approximately 830,000 gallons of liquid, radioactive, sodium-bearing waste (SBW) are stored in three 300,000-gallon tanks at the Idaho Nuclear Technology and Engineering Center (INTEC) Tank Farm. Designing and permitting a SBW treatment facility requires characterization of the waste. This report documents the organic content of the current Tank Farm waste. The waste in tanks VES-WM-188 and VES-WM-189 have been analyzed. The VES-WM-189 waste contains very low concentrations (less than laboratory detectable concentrations of about ten parts per billion) of specific volatile and semi-volatile organic compounds, and less than one gram per liter of total organic carbon. The waste in VES-WM-188 also has very low concentrations of specific volatile organic compounds (generally less than detectable amounts), no detectable polychlorinated biphenyls, and less than one gram per liter of total organic carbon. The semi-volatile organic analysis of the VES-WM-188 waste was not successful. The composition of the waste in VES-WM-187 has changed recently, due to transfers of waste in and out of the tank associated with tank cleaning activities elsewhere in the Tank Farm. Consequently, the waste currently in VES-WM-187 has not been analyzed for organic compounds. The waste in all three tanks is the same type (SBW), came from similar sources, has undergone the same treatment (concentration by evaporation), and has similar chemical content and radioactivity. Waste sample data show the concentrations of organic compounds in the current wastes are similar to those of historical wastes from which the waste is derived. Therefore, the organic content of the waste in VES-WM-187 should be similar to that of the waste in VES-WM-188 and VES-WM-189.

There have been four main potential sources of organic compounds in the Tank Farm waste. They include the uranium extraction and purification processes, the calcination facilities, the analytical laboratories, and equipment decontamination activities. Although some INTEC aqueous wastes had the potential to contain small amounts of organic compounds, the INTEC liquid waste storage and treatment conditions (high nitric acid concentration, concentration of the waste by evaporation, waste agitation, and the use of steam jets and air lifts to transfer waste eliminated most of the volatile and semi-volatile organic compounds from the wastes. Historical analytical data show there have generally been no reproducible detections of specific volatile or semi-volatile organic compounds in the Tank Farm wastes. The few volatile and semi-volatile organic compounds that have been detected were present in very low concentrations, often noted as laboratory contaminants, found in trip blanks, and generally not found in repeated analyses of the same waste. Therefore, their presence in detectable concentrations is suspect. Current and historical analytical data confirm the total organic content of Tank Farm wastes is low (less than 1 gram per liter).

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Organic Compounds in INTEC Tank Farm Waste

1. INTRODUCTION

Spent nuclear fuel was reprocessed between 1953 and 1992 at the Idaho Nuclear Technology and Engineering Center (INTEC), formerly called the Idaho Chemical Processing Plant (ICPP). Fuel reprocessing recovered enriched uranium and valuable nuclear reaction byproducts for the Department of Energy (DOE). Fuel reprocessing also generated radioactive liquid wastes that were stored in the INTEC Tank Farm. Between 1963 and 2000, most of the liquid waste was removed from the Tank Farm and converted into a solid, granular form called calcine. In April 1992, the DOE announced that spent nuclear fuel would no longer be reprocessed and initiated a shutdown of the reprocessing facilities at INTEC. Although fuel reprocessing ceased in 1992, calcination of the Tank Farm waste continued through 2000, when it ended pending a determination on how to treat the remaining waste. During the 40 years of calciner operation, approximately eight million gallons of liquid waste were removed from the Tank Farm and converted into 156,000 cubic feet of calcine (Staiger and Swenson 2005). The calcine is currently stored in six calcined solids storage facilities pending a decision on its final treatment and disposition.

Although the bulk of the liquid waste that was sent to the Tank Farm was removed and calcined, approximately 830,000 gallons of waste remain in three 300,000-gallon tanks. Designing and permitting a treatment facility for the remaining waste requires characterization of the waste. The chemical content and radioactivity of the waste have been documented elsewhere. This report documents the organic content of the waste, based upon historical and recent waste sample analyses, as well as process knowledge.

There have been four primary potential sources of organics to the Tank Farm. They include the raffinates from the uranium extraction and purification processes, waste (primarily off-gas scrubbing solution) from the calcination facilities, analytical laboratory wastes, and spent decontamination solution. This report describes the potential sources of organic compounds in the Tank Farm waste. It provides historical sample data that show the organic compound concentrations in the Tank Farm wastes were small, regardless of the type of waste or potential source of organics. Although some wastes may have contained low concentrations of organics when they were generated, historical sample data show there have generally been no detectable, specific, volatile organic compounds (VOCs) or semi-volatile organic compounds (SVOCs) in the Tank Farm wastes. The liquid waste storage conditions and treatment systems destroyed the bulk of the VOCs and SVOCs that may have originally been in the wastes. The historical analytical data are presented because the current wastes are derived from historical wastes, and current waste compositions can be inferred from historical data when current data are not available. The historical data, current data, and process knowledge provide assurance that the organic content of the current waste is known, even for waste that has not been analyzed for organics.

This report provides recent analytical data to document the organic content of the current Tank Farm wastes. The waste currently in VES-WM-189 (one of the three tanks that store waste) has been characterized for VOCs, SVOCs, and total organic carbon. The waste in VES-WM-188 has been analyzed for VOCs, polychlorinated biphenyls (PCBs), and total organic carbon. The waste currently in VES-WM-187 has not been analyzed for organic compounds. The waste in all three tanks is the same type of waste, has similar chemical composition, and came from the same or similar sources. All three tanks contain concentrate from the evaporation of wastes previously stored in the Tank Farm. Much of that waste was analyzed for organics prior to its evaporation. Both the evaporated concentrate and its predecessor solutions contained similar concentrations of organic compounds. Therefore, although not all of the current wastes have been fully characterized for organics, their organic content is similar to wastes that have been analyzed (each other and historical wastes).

2. SOURCES OF ORGANICS IN TANK FARM WASTE

The INTEC Tank Farm has received and stored radioactive, aqueous wastes since 1953. The Tank Farm received wastes from a variety of sources. Some of the wastes had the potential to contain small amounts of organic compounds. There have been four primary potential sources of organics to the Tank Farm; the uranium extraction and purification processes, the calcination facilities, analytical laboratories, and equipment decontamination activities.

2.1 Organics in Fuel Reprocessing Waste

Reprocessing spent nuclear fuel consisted of dissolving the fuel with acid, recovering enriched uranium from the acidic, dissolver-product solution, and purifying the recovered uranium. The uranium recovery and purification processes included three steps, often called “cycles.” The first cycle separated the uranium in the dissolver-product solution from the bulk of the fission products, cladding material, and other components of the spent nuclear fuel. The second and third cycles purified the uranium by separating it from actinides such as plutonium. Each of the uranium recovery and purification cycles used an organic solution to selectively extract the uranium from the aqueous feed stream. Each uranium recovery and purification cycle produced an aqueous waste (raffinate) that was stored in the Tank Farm. First-cycle raffinate was the single largest source of waste to the Tank Farm waste and contained the bulk of the radioactive fission products originally in the fuel. The second and third-cycle raffinates were smaller in volume and contained much less radioactivity than first-cycle raffinate.

The organic extractants used in the uranium recovery and purification processes were potential sources of organic compounds in the Tank Farm waste. Originally, all three fuel-reprocessing cycles used hexone (methyl isobutyl ketone or 4-methyl-2-pentanone) as the organic extractant. INTEC changed the fuel reprocessing chemistry in the late 1950s and began using a solution of tributyl phosphate (TBP) dissolved in kerosene as the first-cycle organic extractant. The second and third-cycle uranium purification processes continued to use hexone as the organic extractant.

Organic contamination of the fuel reprocessing raffinates was possible from the mixing of aqueous and organic solutions during uranium recovery and purification. Hexone, the organic used in the original first-cycle uranium extraction system and in the second and third-cycle uranium purification processes, is slightly soluble in water (about 2 percent or 20 g/l). Therefore, first-cycle raffinate from the 1950s and all of the second and third-cycle raffinates likely contained some hexone when they were initially produced. The kerosene used in the first-cycle extraction process during most of the fuel reprocessing history is “insoluble” in aqueous solutions. However, trace amounts, less than the laboratory detection quantities of a few parts per billion (ppb), may have been in the first-cycle raffinate sent to the Tank Farm after the late 1950s.

Fuel reprocessing no longer occurs at INTEC. The last first-cycle raffinate was generated in the late 1980s. The last second and third-cycle raffinates were generated in the early 1990s. Virtually all of the first-cycle raffinate was removed from the Tank Farm by 1998 and converted into a solid, granular form (calcine). Fuel reprocessing has not been a potential source of organic compounds to the Tank Farm since the early 1990s.

2.2 Organics in Calcination Facility Waste

Some waste from the calcination facilities was a potential source of organics to the Tank Farm. From August 1970 through May 2000, the calcination facilities burned kerosene to generate heat for the

calcination process. The kerosene was atomized with oxygen and sprayed into the fluidized calciner bed where it burned. The heat of combustion vaporized the water from the Tank Farm waste, leaving the dissolved constituents as a solid granular product called calcine. This method of burning kerosene within the fluidized bed of the calciners was called in-bed combustion (IBC).

The majority of the kerosene burned efficiently in the calciners. However, the relatively cool operating temperature range (500-600°C) of the calciners was not high enough for highly efficient combustion of the more stable and difficult to oxidize kerosene components such as aromatic compounds. Consequently, some products of incomplete combustion (PICs) formed. An extensive sampling program found small concentrations of PICs in the calciner off gas during emissions inventory testing (Boardman et. al. 1999, Young et. al. 2000, and Boardman et. al. 2001).

An off-gas quench and scrub system removed some of the PICs from the calciner off gas. Analyses of off-gas scrub solution samples obtained during the emissions testing program in 1999 and 2000 found low concentrations [<1 part per million (ppm)] of a few PICs (Young 2000). The bulk of the scrub solution was recycled into the calciner feed system, and the PICs in the scrub solution were destroyed or volatilized when they were fed to the calciner. However, during process upsets or following a calciner shutdown, some calciner scrub solution was sent to the Tank Farm. That scrub solution was a potential source of organics (PICs) to the Tank Farm.

Calcination of Tank Farm waste ceased in May 2000. The calciner scrub solution, with its low level of PICs, is no longer a potential source of organics to the Tank Farm.

2.3 Organics in Laboratory Waste

The INTEC analytical laboratories have been a potential source of organics to the Tank Farm. The INTEC laboratories use small quantities (gallon, pint, or smaller) of organic reagents in various analytical procedures. The laboratories do not send waste organic solutions to the Tank Farm. However, the laboratory disposes radioactive, aqueous wastes to the Process Equipment Waste (PEW) Evaporator feed collection system. Some of those wastes may be contaminated with organic reagents that are soluble in aqueous solutions. The PEW Evaporator feed system collects dilute, low-activity, aqueous wastes from a variety of sources, concentrates the wastes, and sends the concentrate to the Tank Farm. Thus, organic-contaminated wastes from the analytical laboratories are a potential source of organics to the Tank Farm via the PEW Evaporator.

Although the laboratories continue to operate today, the INTEC Liquid Waste Management System Permit (Volume 14) requires the analytical laboratories to maintain very low discharges of organics to the PEW Evaporator feed collection system. Historical and current Tank Farm waste analyses have included wastes generated by the analytical laboratories. Any contribution of organics by the analytical laboratories to the Tank Farm waste is included in both current and historical waste sample data.

2.4 Organics in Decontamination Waste

Some of the chemicals used to decontaminate process equipment were a potential source of organics to the Tank Farm. Much of the INTEC process equipment required “hands on” maintenance and repair work. Prior to performing such work, the processes were shut down and the equipment was decontaminated to lower the radiation fields and reduce radiation exposure to maintenance personnel. Various methods were used to decontaminate equipment, including flushing the equipment with cleaning solutions to remove radioactive contamination. The primary cleaning/decontamination reagents were water and nitric acid. However, some of the more aggressive decontamination procedures used organic

compounds as cleaning/decontamination solutions (Johnson and Westra 1979). Organic compounds were typically used to complex radionuclides that were present as metal ions and prevent them from adsorbing onto the surface of the equipment.

Most of the acid-resistant metals (stainless steels) used in the INTEC processes had protective metal-oxide surface films that adsorbed radionuclides from waste solutions. In some cases, films or scale formed on the surface of equipment by deposition of species from the solution having low or marginal solubility. Such surface films also adsorbed radionuclides. Sometimes, equipment decontamination required the removal of the protective metal oxide film and scale in order to remove the adsorbed radionuclides. Removal of the surface films was done using corrosive decontamination reagents such as alkaline or acidic permanganate and oxalic acid. Radionuclides that were removed with the surface film were kept in solution (preventing their re-adsorption onto the equipment surfaces) by the addition of anionic organic compounds that formed stable complexes with the cationic radionuclides. The organic compounds most commonly used for such complexing were tartaric acid, citric acid, and ethylenediaminetetraacetic acid (EDTA). The radionuclide/organic complexes were rinsed from the equipment with the spent decontamination solution.

Most of the spent decontamination solution that contained organic chemicals was sent to the PEW Evaporator, where it was combined with other dilute wastes and concentrated. The Evaporator concentrate was sent to the Tank Farm for storage. Thus, decontamination reagents were a potential source of organic compounds in the Tank Farm waste.

3. ORGANIC CONTENT OF TANK FARM WASTES

The organic content of the Tank Farm waste was affected by the waste storage and treatment conditions. Originally segregation of Tank Farm wastes made some wastes more prone to have some organics than other wastes. However, all of the current wastes have been blended and concentrated, thus homogenizing the wastes and eliminating the historical segregation factor. The waste chemistry, especially the nitric acid content of the waste, has also affected the organic content of the waste. Waste treatment and storage conditions, including concentration of the wastes by evaporation, agitation (air sparging), and transferring wastes with steam powered jet pumps also affected the concentrations of organics in the waste.

3.1 Storage of Tank Farm Wastes

Originally, first-cycle raffinate was stored separately from other wastes because of its high fission product content and heat generation rate. First-cycle raffinate had design requirements (such as cooled tanks) that other wastes did not have. First-cycle raffinate had the potential for organic contamination from the hexone (1950s) and TBP/kerosene (1960s through 1980s) that were used in the first-cycle process.

Second and third-cycle raffinates were originally stored with the PEW Evaporator concentrate due to their low fission product activity and heat generation rates. With time, this waste became known by its current name of sodium-bearing waste (SBW). The name came from the relatively high sodium ion concentration (1-2 molar) in the waste. The high sodium concentration came from wastes generated by scrubbers, ion exchangers, and equipment decontamination that used sodium-containing chemicals such as sodium carbonate and sodium hydroxide. Most of the SBW began as dilute waste that was concentrated in the PEW Evaporator. The resulting concentrate was sent to the Tank Farm. The SBW had the potential to contain organics from second and third-cycle raffinates (hexone) and the PEW Evaporator concentrate (laboratory reagents and decontamination chemicals).

Over time, the waste storage philosophy (and plant piping configuration) changed. After the 1950s, most of the second-cycle raffinate was stored with the first-cycle raffinate (instead of the SBW) because it was chemically compatible with first-cycle raffinate and the calcination process. This provided a potential source of hexone to the first-cycle raffinate. The third-cycle raffinate was stored with the PEW Evaporator concentrate until the 1980s, when piping configuration changes allowed it to be stored with the first-cycle raffinate.

By 1998, only SBW remained in the INTEC Tank Farm. From 1990 through 2000 the SBW was calcined, and from 2000 through 2004 the remaining SBW was blended and concentrated by evaporation. This reduced the total waste volume and allowed several tanks to be emptied and removed from service. It also homogenized the inventory of the SBW currently stored in the INTEC Tank Farm.

3.2 Destruction of Organics in Tank Farm Wastes

Although there were potential sources of organics in the Tank Farm wastes, laboratory tests showed most of the VOCs and SVOCs that may have originally been in the wastes were destroyed by the chemistry, treatment, and storage conditions of the waste. Studies and tests by Radian (1995) and Science Applications International Corporation, or SAIC, (2002) evaluated the fate of organic compounds in Tank Farm wastes. The Radian test spiked simulated Tank Farm waste with 21 volatile and 23 semi-volatile target organic compounds. The spiked solutions were sampled and analyzed over a month-long period. The test found the concentrations of both the target VOCs and SVOCs in the simulated waste generally decreased over time. The concentrations of some organics decreased very rapidly, from concentrations of several thousand ppb to less than detectable quantities (typically about 10 ppb) in a few hours to days.

The rate of decrease depended on the reactivity of each individual organic component. A similar study by SAIC also found a decrease in the organic content of organic-spiked solutions over time. Both studies concluded the organics were destroyed, decomposed, or volatilized due to the high nitric acid concentration in the waste and the storage conditions of the waste.

Historically, Tank Farm wastes varied in chemical and radiochemical composition, depending on the process that generated the waste. However, one common factor among the Tank Farm wastes was a high (1-3 molar) nitric acid concentration. This was due to the extensive use of nitric acid in fuel reprocessing, as a decontamination chemical, in the calciner off-gas scrubbing systems, and elsewhere at INTEC. Based on the Radian and SAIC studies, the nitric acid in the waste likely destroyed most of the VOCs and SVOCs that may have originally been in the Tank Farm wastes.

Neither the Radian nor the SAIC study included the effect of evaporation on the amount of organics in the waste. The evaporation process accelerates the destruction and loss of organics. Computer simulations of the behavior of VOCs and SVOCs in the PEW Evaporator showed most of the organics in the dilute feed solution volatilized during the evaporation process and were not in the concentrate sent to the Tank Farm (Schindler 1999). The computer simulations used commercially available software [ASPEN PLUS™ and OLI System Incorporated's ESP (Environmental Simulation Program)] to estimate the concentrations of organics in the PEW Evaporator concentrate. The computer simulations evaluated 17 VOCs and SVOCs that may have entered the PEW Evaporator feed system, based on INTEC process knowledge, chemical usage, waste sample results, etc. The study concluded no more than one percent of any of the organic compounds evaluated were retained in the Evaporator concentrate. For most organic species, the amount retained in the Evaporator concentrate was several orders of magnitude less than one percent of the amount in the feed solution. The amount retained in the concentrate depended on the solubility and volatility of each compound. Therefore, although some of the dilute wastes sent to the PEW Evaporator may have contained VOCs or SVOCs, virtually none of them were retained in the concentrate that was sent to the Tank Farm.

Historically, evaporators concentrated most of the SBW before it was sent to the Tank Farm. Evaporators in the fuel reprocessing facility concentrated the second and third-cycle raffinates, and the PEW Evaporator concentrated most of the rest of the SBW. In addition, the Evaporator Tank System (ETS), also known as the high-level liquid waste (HLLW) evaporator, recently concentrated the SBW remaining in the Tank Farm.

As a result of the liquid waste treatment, chemistry, and storage conditions, the Tank Farm waste contains very low concentrations (typically less than laboratory detection values) of VOCs and SVOCs.

3.3 Organic Compound Data for Historical Tank Farm Wastes

Hundreds of samples of Tank Farm waste have been analyzed over the 50-year history of the Tank Farm. The bulk of the samples were analyzed for chemicals and radionuclides necessary for the operation of the Tank Farm, calciners, and other waste treatment processes. The analyses included the principal waste components (such as aluminum (Al), zirconium (Zr), and fluoride), constituents such as chloride that were significant to operational concerns such as corrosion, and radionuclides such as cesium (Cs-137) and strontium (Sr-90) that were important to radiation shielding and dose calculations. However, prior to 1990, there were few, if any, detailed analyses for organic compounds in the Tank Farm waste. The concentration of organics had been presumed to be low by process knowledge.

Beginning in 1990, Tank Farm waste samples were analyzed to characterize the waste in compliance with the Resource Conservation and Recovery Act (RCRA). The RCRA waste characterization included organic analyses. The Tank Farm wastes sampled since 1990 have included the various types of wastes

that have been generated and stored throughout the history of the Tank Farm. The sampled wastes include first-cycle (Al and Zr) raffinates, second and third-cycle raffinates, SBW, and mixed wastes (blends of SBW, calciner scrub and decontamination solution, fuel reprocessing raffinates, etc.). The organic analyses have included VOCs, SVOCs, PCBs, and total organic carbon.

Historical Tank Farm waste samples have generally contained no (detectable) specific, target VOCs or SVOCs, regardless of the type or source of the waste. The total concentration of specific and tentatively identified VOCs and SVOCs has typically been less than one part per million. The total organic carbon has typically been less than one gram per liter.

Organic compound data for historical Tank Farm wastes are presented in this report because they help validate the data from the recent samples of the current SBW. The current wastes were derived from historical wastes (by blending and concentrating) and therefore should have similar organic content. The current SBW, like that of historical waste, has virtually no specific VOCs or SVOCs and a low (less than 1 g/L) concentration of total organic carbon. The similarity in the organic content of the current and historical wastes provides assurance that the organic data for the current wastes are reliable. The historical data also help provide assurance that the organic content of the waste in VES-WM-187, which is derived from historical wastes but has not been characterized for organics, is similar to that of both historical and current wastes.

The historical organic compound data in this report differ from that in some reports (Abbott et. al. 1999). Such reports used conservative, bounding values for the organic content of Tank Farm wastes, estimated from INTEC chemical receipts, for risk assessments or worst-case dose calculations. Such estimates did not take into consideration any destruction or removal of the organics by acids, evaporation, waste agitation, etc. Such documents acknowledge the organic concentration data from waste sample analyses are much lower for species for which both estimates and analytical data are available.

3.3.1 Volatile Organic Compounds in Historical Tank Farm Wastes

Table 1 includes data from some of the earliest (1990) analyses for VOCs. Table 2 includes later (1993) VOC data. In general, the number of specific analytes increased with time. Thus, the 1990 sample analyses have fewer analytes than subsequent analyses. The sample data in Tables 1 and 2 show historical Tank Farm wastes, with one exception, did not contain repeatable, detectable amounts of specific VOCs. Most of the analytes had concentrations below the laboratory detection limits (about 10 ppb). Small concentrations of VOCs were detected in a few of the waste samples. However, the detected analytes were present in very small concentrations, found in trip blanks and thus noted by the laboratory as likely lab contaminants (such as acetone), and not found in repeated analyses of the same waste.

Hexone (4-methyl 2-butanone) was the exception to the generalization that VOCs were not regularly detected in the Tank Farm wastes. Table 2 shows three waste samples from VES-WM-100 taken in 1993 consistently had detectable levels of hexone. The concentration of hexone was small, from 0.15 to 0.41 ppm, but above the detection level of 0.010 ppm. At the time, VES-WM-100 contained one-year-old second and third-cycle raffinates. The second and third-cycle uranium purification system used hexone as an organic extractant. Hexone is slightly soluble in water, so its presence in the waste was not unexpected.

Table 1. Volatile organic compound data from representative 1990 Tank Farm waste samples.

Waste Tank		WM-182	WM-185	WM-188	WM-188
Sample Log Number		90-10218	90-09042	90-09149	90-09157
Waste Description		First-Cycle Al Raffinate with Large Fraction (30%) Second/Third-Cycle Raffinates	SBW (PEW Evaporator Concentrate and Small Amounts of First, Second, and Third-Cycle Raffinates)	First-Cycle Zr Raffinate	First-Cycle Zr Raffinate
Volatile Organic Compound	CAS Number	microgram/kg (ppb)	microgram/kg (ppb)	microgram/kg (ppb)	microgram/kg (ppb)
1,1,1-Trichloroethane	71-55-6	<1.64	<1.6	<1.76	<1.74
Acetone	67-64-1	43 ¹	<20.4	<26.4	<26.1
Benzene	71-43-2	9.4 ¹	<9.38	<10.3	<10.2
Carbon Tetrachloride	56-23-5	<1.64	<1.6	<1.76	<1.74
Chloroform	67-66-3	<2.46	<2.4	<2.64	<1.74
Hexone	108-10-1	<7.37	<7.2	<7.93	<7.82
Methylene Chloride	75-09-2	<6.23	<60.8	<66.9	<66.1
Tetrachloroethylene	127-18-4	<0.82	<0.8	<0.88	<0.87
Trichloroethylene	79-01-6	<1.64	<1.6	<1.76	<1.74
Toluene	108-88-3	<7.9	<7.4	<8.17	<8.06

Note 1. Acetone and benzene were noted as being possible laboratory contaminants for this sample.

The 1993 VES-WM-100 waste was included in Table 2 as a “worst-case” sample in terms of VOCs in Tank Farm wastes. Generally, second and third-cycle raffinates were concentrated in an evaporator, which would have driven off the hexone, prior to being sent to the Tank Farm. The second and third-cycle raffinates in the 1993 VES-WM-100 waste had not been concentrated in an evaporator, resulting in higher than normal hexone concentrations. Although hexone was detected (0.15 to 0.41 ppm) in the VES-WM-100 waste, it was much lower than the amount that likely existed (20,000 ppm or 2%) when the waste was initially generated. This shows the bulk of the hexone had been destroyed or removed, even without evaporation, by the waste storage conditions (nitric acid, air sparging, etc.). The waste in VES-WM-100 was calcined in 1993 and is not part of the SBW currently in the Tank Farm.

The 1993 VES-WM-100 data in Table 2 is for “pure” second and third cycle wastes that had not been evaporated or blended with any other waste. Second and third-cycle wastes were generated in relatively small quantities and were usually blended with other wastes (SBW or first-cycle raffinate) for storage. Typically, Tank Farm wastes contained small fractions of second and third-cycle wastes (less than 10% each) that had been concentrated in an evaporator prior to storage in the Tank Farm. The existing SBW contains a total of about 6% second and third-cycle (combined) raffinate (Loos 2004). Historically, SBW has typically had no detectable hexone, as shown by the sample data on Tables 1 and 2.

Tables 1 and 2 include sample data for waste from tank VES-WM-182. At the time (1990 and 1993), VES-WM-182 contained first-cycle Al raffinate with a higher-than-normal fraction (30% combined) of second and third-cycle raffinates (Loos 2004). Despite its high fraction of second and third-cycle raffinates, the VES-WM-182 waste contained no detectable hexone (<0.010 ppm) in either the 1990 or 1993 sample analyses. The VES-WM-182 waste was typical of historical Tank Farm waste and the current SBW in which the second and third-cycle wastes had been evaporated and blended with other wastes.

Table 2. Volatile organic compound data from representative 1993 Tank Farm waste samples.

Waste Tank		WM-100	WM-180	WM-181	WM-182	WM-185	WM-188	WM-189
Sample Log Number(s)		93-082013, -08216, and -08223	93-020710, -02089, and -021310	93-021411, -02205, and -022314	93-03234 and -050726	93-102912	93-09136	93-092315 and -092413
Waste Description		Second and Third-Cycle Raffinate	SBW (PEW Evaporator Concentrate and Second/Third - Cycle Raffinates)	SBW (PEW Evaporator Concentrate and Second/Third - Cycle Raffinates)	First-Cycle Al Raffinate with Large Fraction (30%) of Second/Third -Cycle Raffinate	SBW with Small Fraction of First-Cycle Raffinate	First-Cycle Zr (Fluorinel) Raffinate	Mixture: Primarily NWCF Scrub and Decon Solution
Volatile Organic Compound	CAS Number	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L
1,1,1-Trichloroethane	71-55-6	<50	<10	<10	<10	<10	<50	<25
1,1,2,2-Tetrachloroethane	79-34-5	<50	<10	<10	<10	<10	<50	<25
1,1,2-Trichloroethane	79-00-5	<50	<10	<10	<10	<10	<50	<25
1,1-Dichloroethane	75-34-3	<50	<10	<10	<10	<10	<50	<25
1,1-Dichloroethene	75-35-4	<50	NA	NA	NA	<10	<50	<25
1,2-Dichloroethane	107-06-2	<50	<10	<10	<10	<10	<50	<25
1,2-Dichloropropane	78-87-5	<50	<10	<10	<10	<10	<50	<25
2-Butanone (methyl ethyl ketone)	78-93-3	<50 to 54	NA	NA	NA	<10	<50	<25
2-Hexanone	591-78-6	<50	1-2 ¹	5 to 35 ¹	<10	<10	<50	<25
4-Methyl-2-pentanone (methyl isobutyl ketone or hexone)	108-10-1	150 to 410	1 ² and <10	2 to 4 ² and <10	<10	<10	<50	<25
Acetone	67-64-1	1000 to 1700 ³	NA	NA	Note 4	<10	68 ⁶	150 to 720 ³
Benzene	71-43-2	<50	<10	<10	<10	<10	<50	<25
Bromodichloromethane	75-27-4	<50	<10	<10	<10	<10	<50	<25
Bromoform	75-25-2	<50	<10	<10	<10	<10	<50	<25
Bromomethane	74-83-9	<50	NA	NA	NA	<10	170 ⁶	41 to 170 ⁵
Carbon disulfide	75-15-0	<50	NA	NA	NA	<10	<50	<25
Carbon tetrachloride	56-23-5	<50	<10	<10	<10	<10	<50	<25
Chlorobenzene	108-90-7	NA	NA	NA	NA	<10	<50	<25
Chloroform	67-66-3	<50	<10	<10	<10	<10	<50	<25

See notes at end of table on next page.

Table 2. Volatile organic compound data from representative 1993 Tank Farm waste samples. (Continued)

Waste Tank		WM-100	WM-180	WM-181	WM-182	WM-185	WM-188	WM-189
Waste Storage Tank and Sample Log Number		Logs 93-082013, 08216, and 08223	Logs 93-020710, 02089, and 021310	Logs 93-021411, 02205, and 022314	Logs 93-03234 and 050726	Log 93-102912	Log 93-09136	Logs 93-092315 and 092413
Waste Description		Second and Third Cycle Raffinate	SBW (PEW Evaporator Concentrate and Second/Third-Cycle Raffinates)	SBW (PEW Evaporator Concentrate and Second/Third-Cycle Raffinates)	First-Cycle Al Raffinate with Large Fraction (30%) of Second/Third-Cycle Raffinate	SBW (PEW Evaporator Concentrate and Second/Third-Cycle Raffinates)	First-Cycle Zr Raffinate	Mixture: Primarily NWCF (Scrub and Decon Solution)
Volatile Organic Compound	CAS Number	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L	microgram/L
Chloromethane	74-87-3	<50	NA	NA	NA	<10	300 ⁶	<25
cis-1,2-Dichloroethene	156-59-2	<50	<10	<10	<10	<10	<50	<25
cis-1,3-Dichloropropene	10061-01-5	<50	<10	<10	<10	<10	<50	<25
Dibromochloromethane	124-48-1	<50	<10	<10	<10	<10	<50	<25
Ethylbenzene	100-41-4	<50	<10	<10	<10	<10	<50	<25
Methylene Chloride	75-09-2	<50	<10	<10	<10	<10	62	<25
o-Xylene	95-47-6	<50	<10	<10	<10	<10	<50	<25
Styrene	100-42-5	<50	<10	<10	<10	<10	<50	<25
Tetrachloroethene	127-18-4	<50	<10	<10	<10	<10	<50	<25
Toluene	108-88-3	<50	<10	<10	<10	<10	<50	<25
trans-1,2-Dichloroethene	156-60-5	<50	<10	<10	<10	<10	<50	<25
trans-1,3-Dichloropropene	10061-02-6	<50	<10	<10	<10	<10	<50	<25
Trichloroethene	79-01-6	<50	<10	<10	<10	<10	<50	<25
Vinyl Chloride	75-01-4	<50	NA	NA	NA	<10	<50	<25
Xylene, Isomers m and p	1330-20-7	<50	<10	<10	<10	<10	<50	<25
Note 1. 2-Hexanone was estimated at less than the minimum qualification level (MQL). Found in VES-WM-181 trip blank and was likely a lab contaminant.								
Note 2. Hexone was estimated at less than the minimum qualification level (MQL). Hexone was noted by the lab as a possible lab contaminant.								
Note 3. Acetone was a possible lab contaminant as it was also in trip or system blank.								
Note 4. Acetone was a tentatively identified compound but not estimated. It was identified as a possible lab contaminant.								
Note 5. Bromomethane was detected in both the trip and system blanks. It was a possible laboratory contaminant.								
Note 6. Though not specified for the VES-WM-188 sample, acetone, bromomethane, and chloromethane were common lab contaminants found in trip or system blanks of other samples (i.e. VES-WM-189 sample)								
NA = Not Analyzed								

Table 2 and other tables in this report often include data from multiple samples from a given tank of waste. This is evident by the information in the “Sample Log Number” line which often lists multiple log numbers (corresponding to multiple samples) for a given tank of waste. For the purpose of brevity, data from multiple samples from a given waste are typically included in a single column under the tank number. Usually, specific analytes were not detected in the waste samples, and the laboratory detection value is given in the data tables. In the few cases where multiple samples contained varying detected concentrations of a given analyte, the data tables show the lowest and highest detected value from among the multiple samples of the waste.

3.3.2 Semi-volatile Organic Compounds in Historical Tank Farm Waste

Table 3 shows the results of eight SVOC sample analyses of four wastes in the mid to late 1990s. Table 3 includes two samples of first-cycle Zr raffinate, four samples of SBW, and two samples of mixed wastes (blends of SBW, calciner scrub and decontamination solution, fuel reprocessing raffinates, etc.). Three waste samples came from VES-WM-185; two in 1993 and one in 1999 (the first numbers, 93 and 99, in the sample log number correspond to the year in which the sample was taken). The three VES-WM-185 samples came from the same waste. There were no waste transfers into VES-WM-185 between the two sample dates, thus its waste composition did not change. Three samples came from waste from VES-WM-189; one in 1993, one in 1996, and one in 1999. The 1993 and 1996 VES-WM-189 samples came from virtually the same waste. A small amount of waste was added to VES-WM-189 after the 1993 sample was taken, increasing the waste volume by about 10%. However, the source of the new waste was the same as the original waste, so there should have been no significant change in the waste composition. VES-WM-189 was emptied and refilled between 1996 and 1999. Therefore, the 1999 waste in VES-WM-189 was different than the 1993/1996 waste.

The sample data in Table 3 generally show no (detectable) specific SVOCs in the Tank Farm waste. The laboratory detection values generally varied from 5 to 25 parts per billion (ppb). The number of specific analytes increased with time, so the 1999 and 1996 analyte list is more extensive than that of 1993. Some nitrated aromatics (2-nitophenyl and 2-4-dinitrophenyl) were found at low concentrations (<0.10 ppm) in some of the 1993 samples. Nitrated aromatics are possible PICs from the combustion of kerosene in the calciner. Small concentrations (less than 1 ppm) of PICs were detected in the calciner off-gas scrub solution during calciner emissions testing (Boardman et. al. 2001). The 1993 VES-WM-189 waste included a large amount of calciner decontamination and scrub solution that could have contained PICs from the calcination process. However, the nitrated aromatics were found only in the 1993 analysis, not in the subsequent (1996) analysis of the same waste. The reason for this anomaly is not certain. The 1993 analyses may have been inaccurate or the organics may have been destroyed in storage. In any event, the detected concentrations of the nitrated organics in 1993 were low.

The concentrations of specific SVOCs in historical Tank Farm wastes were generally below the laboratory detection limits (5 to 25 ppb). In the few instances when specific SVOCs were detected, the amounts were small (<0.1 ppm) and were not found in repeated analyses of the same or similar wastes.

Table 3. Semi-volatile organic compound data of representative historical Tank Farm wastes.

Waste Tank		WM-189		WM-188	WM-185		WM-189
Waste Description		Mixed Wastes-- Primarily NWCF Scrub and Decon Solution derived from first-cycle raffinate		First Cycle Zr (Fluorinel) Raffinate	SBW --With Small Amount of First-Cycle Raffinate		SBW--With NWCF Scrub/Decon Solution and ETS Concentrate
Sample Log Number		93- 092411	96- 06111	93-07174, 93-07175	93-072115 93-07222	99-05241	99- 03111
Semi-Volatile Organic Compound	CAS Number	Concentration (ppb)		Concentration (ppb)	Concentration (ppb)		Concentration (ppb)
1,2,4-Trichlorobenzene	120-82-1	<10	<6.9	<10	10 ¹	<25	<25
1,2-Dichlorobenzene	95-50-1	<10	<7.3	<10	<10	<25	<25
1,3-Dichlorobenzene	541-73-1	<10	<6.1	<10	<10	<25	<25
1,4-Dichlorobenzene	106-46-7	<10	<1.8	<10	10 ¹	<25	<25
2,2'-Oxybis(1-chloropropane)	108-60-1	<10	<6.1	<10	<10	<25	<25
2,4,5-Trichlorophenol	95-95-4	<10	<17.4	<10	<10	<25	<25
2,4,6-Trichlorophenol	88-06-2	<10	<10.1	<10	<10	<25	<25
2,4-Dichlorophenol	120-83-2	<10	<7.6	<10	<10	<25	<25
2,4-Dimethylphenol	105-67-9	<10	<16.6	<10	<10	<25	<25
2,4-Dinitrophenol	51-28-5	81.14	<26.6	10 ¹	10 ¹	<25	<25
2,6-Dinitrotoluene	606-20-2	<10	<7.9	10 ¹	<10	<25	<25
2-Chloronaphthalene	91-58-7	<10	<10.4	<10	<10	<25	<25
2-Chlorophenol	95-57-8	<10	<5.6	<10	<10	<25	<25
2-Methylnaphthalene	91-57-6	<10	<7.0	<10	<10	<25	<25
2-Methylphenol	95-48-7	<10	<5.0	<10	<10	<25	<25
2-Nitroaniline	88-74-4	10 ¹	<6.3	<10	<10	<25	<25
2-Nitrophenol	88-75-5	89.47	<7.3	35.32	19.55	<25	<25
3-Nitroaniline	99-09-2	<10	<6.3	<10	10 ¹	<25	<25
4-Chloro-3-methylphenol	59-50-7	<10	<7.6	<10	<10	<25	<25
4-Chloroaniline	106-47-8	<10	<26.9	10 ¹	<10	<25	<25
4-Methylphenol	106-44-5	10 ¹	<5.4	10 ¹	<10	<25	<25
Acenaphthene	83-82-9	<10	<5.6	<10	38.64	<25	<25
Acenaphthylene	208-96-8	<10	<6.9	<10	<10	<25	<25
Bis(2-chloroethoxy)methane	111-91-1	<10	<7.7	<10	<10	<25	<25
Bis(2-Chloroethyl)ether	111-44-4	<10	<6.9	<10	<10	<25	<25
Dimethylphthalate	131-11-3	<10	<6.9	<10	<10	<25	<25
Hexachlorobutadiene	87-68-3	<10	<9.8	<10	<10	<25	<25
Hexachlorocyclopentadiene	77-47-4	<10	<13.0	<10	<10	<25	<25
Hexachloroethane	67-72-1	<10	<8.5	<10	<10	<25	<25
Isophorone	78-59-1	<10	<7.2	<10	<10	<25	<25
Naphthalene	91-20-3	<10	<7.7	<10	10 ¹	<25	<25
Nitrobenzene	98-95-3	<10	<8.7	<10	<10	<25	<25
N-Nitroso-dimethylamine	62-75-9	<10	<10.7	<10	<10	<25	<25
N-Nitroso-di-n-propylamine	621-64-7	<10	<13.1	<10	<10	<25	<25
Phenol	108-95-2	<10	<5.7	<10	<10	<25	<25

Note 1. Estimated value (below minimum quantification level).

NA = Not Analyzed

Table 3. Semi-volatile organic compound data of representative historical Tank Farm wastes. (continued)

Waste Tank		WM-189		WM-188	WM-185		WM-189
Waste Description		Mixed Wastes-- Primarily NWCF Scrub and Decon Solution		First-Cycle Zr (Fluorinel) Raffinate	SBW --With Small Amount of First- Cycle Raffinate		SBW--With NWCF Scrub/Decon Solution and ETS Concentrate
Sample Log Number		93- 092411	96- 06111	93-07174, 93-07175	93-72115 93-07222	99- 05241	99-03111
Semi-Volatile Organic Compound	CAS Number	Concentration (ppb)		Concentration (ppb)	Concentration (ppb)		Concentration (ppb)
2,4-Dinitrotoluene	121-14-2	NA	<9.8	NA	NA	<25	<25
3,3'-Dichlorobenzidine	91-94-1	NA	<66.3	NA	NA	<25	<25
4,6-Dinitro-2-methylphenol	534-52-1	NA	<5	NA	NA	<25	<25
4-Bromophenyl-phenylether	101-55-3	NA	<6.7	NA	NA	<25	<25
4-Chlorophenyl-phenylether	7005-72-3	NA	<7.3	NA	NA	<25	<25
4-Nitroaniline	100-01-6	NA	<4.2	NA	NA	<25	<25
4-Nitrophenol	100-02-7	NA	<18.6	NA	NA	<25	<25
Anthracene	120-12-7	NA	<5.2	NA	NA	<25	<25
Azobenzene	103-33-3	NA	<10	NA	NA	<25	<25
Benzo(a)anthracene	56-55-3	NA	<7.8	NA	NA	<25	<25
Benzo(a)pyrene	50-32-8	NA	<1.3	NA	NA	<25	<500
Benzo(b)fluoranthene	205-99-2	NA	<7.3	NA	NA	<25	<500
Benzo(g,h,i)perylene	191-24-2	NA	<3.2	NA	NA	<25	<500
Benzo(k)fluoranthene	207-08-9	NA	<5.7	NA	NA	<25	<500
bis(2-Ethylhexyl)phthalate	117-81-7	NA	<7.9	NA	NA	<25	<25
Butylbenzylphthalate	85-68-7	NA	<8.2	NA	NA	<25	<25
Carbazole	86-74-8	NA	<10	NA	NA	<25	<25
Chrysene	218-01-9	NA	<8.3	NA	NA	<25	<25
Dibenzo(a,h)anthracene	53-70-3	NA	<4.8	NA	NA	<25	<500
Dibenzofuran	132-64-9	NA	<4.1	NA	NA	<25	<25
Diethylphthalate	84-66-2	NA	<8.5	NA	NA	<25	<25
Di-n-butylphthalate	84-74-2	NA	<2.6	NA	NA	<25	<25
Di-n-octylphthalate	117-84-0	NA	<2.9	NA	NA	<25	<500
Fluoranthene	206-44-0	NA	<8.2	NA	NA	<25	<25
Fluorene	86-73-7	NA	<4.6	NA	NA	<25	<25
Hexachlorobenzene	118-74-1	NA	<7	NA	NA	<25	<25
Indeno(1,2,3-cd)pyrene	193-39-5	NA	<35.5	NA	NA	<25	<500
N-Nitrosodiphenylamine	86-30-6	NA	<10	NA	NA	<25	<25
Pentachlorophenol	87-86-5	NA	<13.3	NA	NA	<25	<25
Phenanthrene	85-01-8	NA	<6.5	NA	NA	<25	<25
Pyrene	129-00-0	NA	<11.7	NA	NA	<25	<25
Pyridine	110-86-1	NA	<10	NA	NA	<25	<25
Tri-n-butyl phosphate	126-73-8	NA	<10	NA	NA	<25	<25

Note 1. Estimated value (below minimum quantification level).

NA = Not Analyzed

3.3.3 Total Organic Carbon in Historical Tank Farm Waste

Several historical Tank Farm wastes were analyzed for total organic carbon (TOC). This analysis determines the total concentration of organic carbon from VOCs, SVOCs, and other organic molecules whose volatility is too low to be classified as either a VOC or SVOC. The TOC analysis would include residues from decontamination chemicals that would not be found with a VOC or SVOC analysis. Table 4 shows typical TOC data for wastes that were primarily SBW and typical of the waste from which the current SBW is derived. Table 4 shows the TOC concentration of multiple analyses of the same waste (VES-WM-189) varied significantly (factor of 4). However, despite the variability, the SBW in the various tanks all had similar TOC concentrations of less than 1 g/l (ranging from 0.1 to 0.6 g/l).

Table 4. Total organic carbon in typical historical Tank Farm wastes.

Waste Tank	WM-189				WM-183	WM-185	WM-189	
Waste Description	Mixed Wastes--Primarily First-Cycle Raffinate and NWCF Scrub/Decon Solution				SBW --With Small Amount of First-Cycle Raffinate	SBW --With Small Amount of First-Cycle Raffinate	SBW--With NWCF Scrub/Decon Solution and ETS Concentrate	
Sample Log Number	96-060311	96-06111	96-080510	96-08283	96-080715	99-05241	99-03111	00-3231
Total Organic Carbon (g/l)	0.466	0.642	0.146	0.128	0.175	0.232	0.204	0.123

3.4 Organic Compounds in Existing Tank Farm Waste

Concentrated SBW is currently stored in three tanks, VES-WM-187, VES-WM-188 and VES-WM-189. The waste in VES-WM-189 has been analyzed for VOCs, SVOCs, and TOC. The waste in VES-WM-188 has been analyzed for VOCs, SVOCs, PCBs, and TOC. It was also analyzed for SVOCs, but the analysis was not successful. The waste in VES-WM-187 has not been analyzed for organics.

3.4.1 Organic Compound Data for Current VES-WM-189 Waste

The waste in VES-WM-189 was sampled in March 2002 and analyzed for organic compounds (sample log numbers 02-03111, 02-03121, and 02-03141). The tank contained 282,000 gallons of waste when it was sampled. After VES-WM-189 was sampled, it received 2,700 gallons of waste in 2004, and “lost” 2,700 gallons due to instrument calibrations, for a net change of zero gallons. The current (August 2005) waste volume in VES-WM-189 is 282,000 gallons. The 2,700 gallons of waste that were added to the tank after it had been sampled were concentrated SBW from the ETS and PEW Evaporator. The new waste came from sources similar to the SBW already in VES-WM-189 when it was sampled. Because the new waste came from sources similar to the sampled waste and is only 1% of the total waste volume, the March 2002 liquid waste sample is representative of the waste currently in VES-WM-189.

Tables 5 and 6 summarize the results of the VOC and SVOC analyses respectively of the VES-WM-189 waste. The tables include both specific analytes and tentatively identified compounds (TICs). The concentrations of most of the analytes are below the laboratory detection value. The few detected analytes have shaded backgrounds to facilitate finding them in the tables. The concentrations of most detected analytes also include one or more letters that are laboratory qualifier flags (LQFs). The LQFs provide information about the detected analyte, such as whether the analyte was detected in a sample blank, was an estimated value, etc. The LQF definitions are provided at the ends of the tables.

Table 5. Volatile organic compounds in the SBW currently stored in VES-WM-189.

Volatile Organic Compound	CAS Number	Sample Log Numbers and Analyte Concentrations (microgram/L)					
		02-03111	02-03111 (repeat)	02-03121	02-03121 (repeat)	02-03141*	02-03141* (repeat)
1,1,1-Trichloroethane	71-55-6	<10	<10	<10	<10	<10	<10
1,1,2,2-Tetrachloroethane	79-34-5	<10	<10	<10	<10	<10	<10
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<10	<10	<10	<10	<10	<10
1,1,2-Trichloroethane	79-00-5	<10	<10	<10	<10	<10	<10
1,1-Dichloroethane	75-34-3	<10	<10	<10	<10	<10	<10
1,1-Dichloroethene	75-35-4	<10	<10	<10	<10	<10	<10
1,2-Dichloroethane	107-06-2	<10	<10	<10	<10	<10	<10
1,2-Dichloropropane	78-87-5	<10	<10	<10	<10	<10	<10
2-Butanone	78-93-3	<10	<10	<10	<10	<10	<10
2-Hexanone	591-78-6	<10	<10	<10	<10	<10	<10
4-Methyl-2-pentanone	108-10-1	<10	<10	<10	<10	<10	<10
Acetone	67-64-1	33 BY	<10	11 BY	6 JBY	<10	<10
Benzene	71-43-2	<10	<10	<10	<10	<10	<10
Bromodichloromethane	75-27-4	<10	<10	<10	<10	<10	<10
Bromoform	75-25-2	<10	<10	<10	<10	<10	<10
Bromomethane	74-83-9	13 B	<10	32 B	<10	59	<10
Carbon disulfide	75-15-0	<10	<10	<10	<10	<10	<10
Carbon tetrachloride	56-23-5	<10	<10	<10	<10	<10	<10
Chlorobenzene	108-90-7	<10	<10	<10	<10	<10	<10
Chloroethane	75-00-3	<10	<10	<10	<10	<10	<10
Chloroform	67-66-3	<10	<10	<10	<10	<10	<10
Chloromethane	74-87-3	23 M	<10	35 M	<10	75 M	<10
cis-1,2-Dichloroethene	156-59-2	<10	<10	<10	<10	<10	<10
cis-1,3-Dichloropropene	10061-01-5	<10	<10	<10	<10	<10	<10
Dibromochloromethane	124-48-1	<10	<10	<10	<10	<10	<10
Ethylbenzene	100-41-4	<10	<10	<10	<10	<10	<10
Methylene Chloride	75-09-2	<10	<10	<10	<10	<10	<10
o-Xylene	95-47-6	<10	<10	<10	<10	<10	<10
Styrene	100-42-5	<10	<10	<10	<10	<10	<10
Tetrachloroethene	127-18-4	<10	<10	<10	<10	<10	<10

Table 5. Volatile organic compounds in the SBW currently stored in VES-WM-189. (Continued)

Volatile Organic Compound	CAS Number	Sample Log Numbers and Analyte Concentrations (microgram/L)					
		02-03111	02-03111 (repeat)	02-03121	02-03121 (repeat)	02-03141	02-03141 (repeat)
trans-1,2-Dichloroethene	156-60-5	<10	<10	<10	<10	<10	<10
trans-1,3-Dichloropropene	10061-02-6	<10	<10	<10	<10	<10	<10
Trichloroethene	79-01-6	<10	<10	<10	<10	<10	<10
Trichlorofluoromethane	75-69-4	<10	<10	<10	<10	<10	<10
Vinyl Chloride	75-01-4	<10	<10	<10	<10	<10	<10
Xylene, Isomers m and p	1330-20-7	<20	<20	<20	<20	<20	<20
Number of Tentatively Identified VOCs (TICs)		3 TICs		1 TIC		5 TICs	
Total mass of TICs (mg/L)		0.031 mg/L		0.016 mg/L		0.161 mg/L	
*All analytes for sample log 020314-1 have LQF = H							

Laboratory Qualifier Flags (LQFs) definitions:

B = analyte also detected in blank

J = estimated (extrapolated) value

M = quantified from first or higher order regression fit calibration curve with correlation coefficient <0.999

Y = analyte is a solvent used in hot cell for other procedures

H = hold time exceeded

Table 6. Semi-volatile organic compounds in the SBW currently stored in VES-WM-189.

Semi-volatile Organic Compound	CAS Number	Sample Log Number and Analyte Concentrations			
		02-03111 (microgm/L)	02-03111 (repeat) (microgm/L)	02-03121 (microgm/L)	02-03141* (microgm/L)
1,2,4-Trichlorobenzene	120-82-1	<6	<6	<6	<6
1,2-Dichlorobenzene	95-50-1	<5	<5	<5	<8
1,3-Dichlorobenzene	541-73-1	<7	<7	<7	<9
1,4-Dichlorobenzene	106-46-7	<8	<8	<8	<9
2,4,5-Trichlorophenol	95-95-4	<4	<4	<4	<8
2,4,6-Trichlorophenol	88-06-2	<12	<12	<12	<9
2,4-Dichlorophenol	120-83-2	<6	<6	<6	<6
2,4-Dimethylphenol	105-67-9	<3	<3	<3	<10
2,4-Dinitrophenol	51-28-5	<13	<13	<13	<8
2,4-Dinitrotoluene	121-14-2	<8	<8	<8	<8
2,6-Dinitrotoluene	606-20-2	<11	<11	<11	<8
2-Chloronaphthalene	91-58-7	<7	<7	<7	<7
2-Chlorophenol	95-57-8	<8	<8	<8	<8
2-Methylnaphthalene	91-57-6	<9	<9	<9	<7
2-Methylphenol (o-Cresol)	95-48-7	<9	<9	<9	<7
2-Nitroaniline	88-74-4	<9	<9	<9	<8
2-Nitrophenol	88-75-5	<8	<8	<8	<8
3 and 4-methylphenol	106-44-5	<11	<11	<11	<5
3,3'-Dichlorobenzidine	91-94-1	<12	<12	<12	<8
3-Nitroaniline	99-09-2	<16	<16	<16	<4
4,6-Dinitro-2-methylphenol	534-52-1	<13	<13	<13	<7
4-Bromophenyl phenyl ether	101-55-3	<12	<12	<12	<8
4-Chloro-3-methylphenol	59-50-7	<6	<6	<6	<5
4-Chloroaniline	106-47-8	<3	<3	<3	<14
4-Chlorophenyl phenyl ether	7005-72-3	<14	<14	<14	<8
4-Nitroaniline	100-01-6	<10	<10	<10	<5
4-Nitrophenol	100-02-7	<30	<30	<30	<2
Acenaphthylene	208-96-8	<6	<6	<6	<6
Anthracene	120-12-7	<8	<8	<8	<6
Azobenzene	103-33-3	<15	<15	<15	<11
Benzo(a)anthracene	56-55-3	<9	<9	<9	<7
Benzo(a)pyrene	50-32-8	<8	<8	<8	<6
Benzo(b)fluoranthene	205-99-2	<8	<8	<8	<6
Benzo(g,h,i)perylene	191-24-2	<8	<8	<8	<6
Benzo(k)fluoranthene	207-08-9	<8	<8	<8	<7
Benzyl butyl phthalate	85-68-7	<9	<9	<9	<10
bis-(2-chloroethoxy)methane	111-91-1	<6	<6	<6	<5
bis-(2-Chloroethyl)ether	111-44-4	<7	<7	<7	<11
bis(2-Chloroisopropyl)ether	108-60-1	<5	<5	<5	<6
bis-(2-ethylhexyl)phthalate	117-81-7	46 M	31 M	<9	25
Carbazole	86-74-8	<6	<6	<6	<6

Table 6. Semi-volatile organic compounds in the SBW currently stored in VES-WM-189. (continued)

Semi-volatile Organic Compound	Semi-volatile Organic Compound	Sample Log Number and Analyte Concentrations			
		020311-1 (microgm/L)	020311-1 (repeat) (microgm/L)	020312-1 (microgm/L)	020314-1 (microgm/L)
Chrysene	218-01-9	<7	<7	<7	<11
Dibenzo(a,h)anthracene	53-70-3	<8	<8	<8	<6
Dibenzofuran	132-64-9	<11	<11	<11	12 J
Diethyl Phthalate	84-66-2	<12	<12	<12	<11
Dimethyl phthalate	131-11-3	<9	<9	<9	<8
Di-n-butyl phthalate	84-74-2	<12	<12	<12	<14
Di-n-octyl phthalate	117-84-0	20	16 J	<6	<7
Fluoranthene	206-44-0	<11	<11	<11	<5
Fluorene	86-73-7	<10	<10	<10	<5
Hexachlorobenzene	118-74-1	<39	<39	<39	<5
Hexachlorobutadiene	87-68-3	<40	<40	<40	<7
Hexachlorocyclopentadiene	77-47-4	<30	<30	<30	<7
Hexachloroethane	67-72-1	<5	<5	<5	<8
Indeno(1,2,3-cd)pyrene	193-39-5	<9	<9	<9	<6
Isophorone	78-59-1	<6	<6	<6	82
Naphthalene	91-20-3	<7	<7	<7	<5
Nitrobenzene	98-95-3	<7	<7	<7	<11
n-Nitrosodimethylamine	62-75-9	<24	<24	<24	<8
n-Nitrosodi-n-propylamine	621-64-7	<9	<9	<9	<8
n-Nitrosodiphenylamine	86-30-6	<7	<7	<7	<9
Pentachlorophenol	87-86-5	<19	<19	<19	<11
Phenanthrene	85-01-8	<6	<6	<6	<6
Phenol	108-95-2	<18	<18	<18	<3
Pyrene	129-00-0	<6	<6	<6	<6
Pyridine	110-86-1	<15	<15	<15	<9
tri-n-butyl phosphate	126-73-8	11 BJM	11 BJM	11 BJM	44
Number of Tentatively Identified SVOCs (TICs)		20 TICs	19 TICs	6 TICs	20 TICs
Total mass of TICs (mg/L)		1.1 mg/L	0.741 mg/L	0.226 mg/L	1.8 mg/L
*All analytes for sample log 020314-1 have LQF = H					

Laboratory Qualifier Flags (LQFs) definitions:

B = analyte also detected in blank

J = estimated (extrapolated) value

M = quantified from first or higher order regression fit calibration curve with a correlation coefficient of <0.999

H = hold time exceeded

Tables 5 and 6 show most of the VOC and SVOC constituents in VES-WM-189 have concentrations below the laboratory detection level (about 10 ppb). The few detected compounds are present in very low concentrations. The VOC and SVOC data in Tables 5 and 6 are consistent with the historical Tank Farm sample data summarized in sections 3.2.1 and 3.2.2 of this report. Some of the detected compounds may have been laboratory contaminants because they were commonly used laboratory reagents (such as acetone), were not consistently detected in all samples, or were detected in the sample blanks.

The TOC content of the three VES-WM-189 samples ranged from 0.513 to 0.624 g/L. These values are similar to the historical TOC data for SBW shown on Table 4.

3.4.2 Organic Compound Data for Current VES-WM-188 Waste

The waste in VES-WM-188 was sampled in November 2002 (sample log 021125-2) when the tank contained 214,000 gallons of waste. The VES-WM-188 sample was successfully analyzed for VOCs, PCBs, and total organic carbon. The sample was also analyzed for SVOCs. The SVOC analysis found no specific analytes above the laboratory detection values and no TICs. However, due to equipment problems, laboratory personnel reported the SVOC analysis had “no meaningful results”.¹ Therefore, the SVOC data are not included in this report.

When it was sampled in November 2002, VES-WM-188 contained 211,000 gallons of SBW. That waste had originally been in VES-WM-181, -184, -185, and -186 and had been concentrated in the ETS. The waste in VES-WM-189 also came from the same tanks and was also concentrated in the ETS. During 2001, the ETS concentrate was added alternately to VES-WM-188 and VES-WM-189 in an effort to equilibrate the waste compositions in the two tanks. Because of this, the wastes in VES-WM-188 and VES-WM-189 are very similar, including their organic content.

After VES-WM-188 was sampled in November 2002, it was filled with additional SBW. Between 2002 and 2004, tanks VES-WM-181, -182, -183, -184, -185 and -186 were cleaned in preparation for RCRA tank closure. The tank heels (residual liquids and solids in the bottom of the tanks) were flushed with demineralized water into VES-WM-187. The liquid that accumulated in VES-WM-187 was concentrated in the ETS, and the concentrate was sent to VES-WM-188. This increased the VES-WM-188 volume to 264,000 gallons by July 2004. The 53,000 gallons of waste came primarily from the same tanks and was concentrated in the same fashion as the 211,000 gallons that were sampled in November 2002. Therefore, the composition of the new (53,000 gallons) of waste was very similar to the waste that had been sampled in November 2002.

In July 2004, the ETS began concentrating the SBW in VES-WM-180. Some of the VES-WM-180 concentrate went into VES-WM-188, bringing its waste volume to its current (August 2005) value of 283,000 gallons. Historical samples of the SBW in VES-WM-180 (Swenson 2004) show its composition was similar to the SBW that had been in VES-WM-181, -184, and -186, which was concentrated and sent to VES-WM-188 and VES-WM-189. The 1993 RCRA characterization of the VES-WM-180 waste (see Table 2) showed it had no (detectable) specific VOCs. Historical analyses of other SBW showed they generally had no (detectable) specific SVOCs (see Table 3). Due to the similarity in waste sources and compositions, the organic content of the 19,000 gallons of concentrate from the evaporation of the VES-WM-180 waste was likely similar to the waste already in VES-WM-188. As a result, the November 2002 sample data is representative of the waste currently in VES-WM-188.

¹ CWI Intranet Memo from J. D. Long to M. C. Swenson, “WM-188 Volatiles Data”, dated June 16, 2005.

Table 7 contains the results of the PCB analysis of the VES-WM-188 waste. The concentrations of all the specific PCBs were less than the laboratory detection values. This is consistent with historical Tank Farm sample data. There are less historical Tank Farm data for PCBs than other organic compounds. This is because PCBs were never part of any INTEC process and were known by process knowledge to have not been in the Tank Farm wastes. Consequently, relatively few analyses of Tank Farm waste have been made for PCBs.

Table 7. Polychlorinated biphenyls in the SBW currently stored in VES-WM-188.

Polychlorinated Biphenyl	CAS Number	Log 021125-2 Concentration (milligram/kg or parts per million)
PCB-1016	12674-11-2	< 0.306
PCB-1221	11104-28-2	< 0.202
PCB-1232	11141-16-5	< 0.247
PCB-1242	53469-21-9	< 0.347
PCB-1248	12672-29-6	< 0.258
PCB-1254	11097-69-1	< 0.298
PCB-1260	11096-82-5	< 0.253

Table 8 summarizes the results of the VOC analysis of the VES-WM-188 waste. The data in Table 8 are consistent with the historical Tank Farm waste VOC analyses summarized in section 3.2.1 and with the current VES-WM-189 waste analysis. The concentrations of VOCs in the VES-WM-188 waste are very low. Most of the specific analytes have concentrations below the laboratory detection level (about 10 ppb). Bromomethane was the only specific analyte detected in the VOC analysis, and it had a very low concentration 33 ppb). Though the bromomethane concentration in Table 8 has no laboratory qualifier flags, it has been noted as a laboratory contaminant in the past (see Tables 2 and 4).

The TOC concentration in the VES-WM-188 waste sample was 0.416 g/L. This value is consistent with the historical SBW data shown on Table 4 and with the VES-WM-189 waste analysis.

3.4.3 Organic Compound Data for Current VES-WM-187 Waste

During the past few years, VES-WM-187 has been the collection tank for the wastes and rinse solutions generated by cleaning other tanks in the INTEC Tank Farm. As such, it has been periodically filled with dilute tank cleaning/flush solution, and then emptied when the dilute waste was concentrated in the ETS. The bulk of the ETS concentrate generated from tank cleaning/flush solutions is now stored in VES-WM-188 and VES-WM-189. Recent samples of the VES-WM-187 waste have been taken, but the analyses have been limited to those species needed for immediate waste treatment (evaporation) and have not included organic compounds.

Some of the waste currently in VES-WM-187 is derived from tank cleaning/flushing solution, similar to those of VES-WM-188 and VES-WM-189. The portion of the VES-WM-187 waste that came from cleaning/flushing solution should have an organic content similar to the wastes in VES-WM-188 and VES-WM-189, which have been analyzed for organics.

Table 8. Volatile organic compounds in the SBW currently stored in VES-WM-188.

Volatile Organic Compound	CAS Number	Log 021125-2 (microgram/kg)
1,1,1-Trichloroethane	71-55-6	<2
1,1,2,2-Tetrachloroethane	79-34-5	<2
1,1,2-Trichloro-1,2,2-trifluoroethane	76-13-1	<2
1,1,2-Trichloroethane	79-00-5	<2
1,1-Dichloroethane	75-34-3	<2
1,1-Dichloroethene	75-35-4	<2
1,2-Dichloroethane	107-06-2	<2
1,2-Dichloropropane	78-87-5	<2
2-Butanone (methyl ethyl ketone)	78-93-3	<4
2-Hexanone	591-78-6	<2
4-Methyl-2-pentanone (methyl isobutyl ketone or hexone)	108-10-1	<2
Acetone	67-64-1	<2
Benzene	71-43-2	<2
Bromodichloromethane	75-27-4	<2
Bromoform	75-25-2	<2
Bromomethane	74-83-9	33
Carbon disulfide	75-15-0	<13
Carbon tetrachloride	56-23-5	<3
Chlorobenzene	108-90-7	<2
Chloroform	67-66-3	<2
Chloromethane	74-87-3	<1
cis-1,2-Dichloroethene	156-59-2	<2
cis-1,3-Dichloropropene	10061-01-5	<2
Dibromochloromethane	124-48-1	<2
Ethylbenzene	100-41-4	<2
Methylene Chloride	75-09-2	<3
o-Xylene	95-47-6	<2
Styrene	100-42-5	<2
Tetrachloroethene	127-18-4	<2
Toluene	108-88-3	<2
trans-1,2-Dichloroethene	156-60-5	<2
trans-1,3-Dichloropropene	10061-02-6	<2
Trichlorofluoromethane	75-69-4	<2
Trichloroethene	79-01-6	<2
Vinyl Chloride	75-01-4	<2
Xylene, Isomers m and p	1330-20-7	<3
Number of Tentatively Identified VOCs (TICs)	NA	1
Total mass of TICs (mg/kg)	NA	0.033

Most (about three fourths) of the waste in VES-WM-187 came from VES-WM-180. During 2004, waste from VES-WM-180 was concentrated in the ETS and most of the concentrate was sent to VES-WM-187. The waste in VES-WM-180 was SBW that came from the same or similar sources as other historical SBW. Historical samples of the SBW in VES-WM-180 (Swenson 2004) show its composition was similar to the SBW that had been in VES-WM-181, -184, and -186 and was concentrated and sent to VES-WM-188 and VES-WM-189. The 1993 RCRA characterization of the VES-WM-180 waste (see Table 2) showed it had no (detectable) specific VOCs. Historical analyses of similar SBW found no (detectable) specific SVOCs (see Table 3).

The consistency of the organic content of recent and historical Tank Farm wastes suggests the organic content of the VES-WM-180 waste was similar to that of other historical SBW that were concentrated in the ETS and whose concentrates are now stored in VES-WM-188 and VES-WM-189. Therefore, due to the similarity of waste sources and compositions, the organic content of the SBW currently stored in VES-WM-187 should be similar to the SBW currently stored in VES-WM-188 and VES-WM-189.

4. CONCLUSION

Some Tank Farm wastes had the potential to contain small amounts of organics when they were initially generated. However, the liquid waste storage and treatment conditions, including high acid content, evaporation, steam jetting, air lifting, and tank agitation destroyed or removed most of the VOCs and SVOCs from the waste.

SBW is currently stored in three 300,000-gallon tanks. The waste in VES-WM-189 has been analyzed for VOCs, SVOCs, and total organic carbon. The waste in VES-WM-188 has been analyzed for VOCs, PCBs, and total organic carbon. The organic compound data from the VES-WM-188 and VES-WM-189 sample analyses are consistent with historical SBW sample data. The wastes in VES-WM-188 and VES-WM-189 generally contain no (detectable) specific VOCs or SVOCs. The few detected VOCs and SVOCs had very low concentrations (less than 0.1 ppm), were rarely detected in repeated analyses of the same waste, and may have been laboratory contaminants. The waste analyses also found no (detectable) PCBs. The total organic carbon concentration in the wastes was also low (less than 1 gram per liter).

The waste currently in VES-WM-187 has not been characterized for organic compounds. However, it is the same general type of waste (SBW) as that stored in VES-WM-188 and VES-WM-189, and came from the same or similar sources. The wastes in all three tanks have had similar storage conditions and waste treatments. The chemistry of all three tanks is similar. Sample analyses have shown the organic content of VES-WM-188 and VES-WM-189 is similar to each other and to historical Tank Farm wastes. Historical data and process knowledge support the conclusion that the organic content of the waste in VES-WM-187 is similar to that of the waste in VES-WM-188 and VES-WM-189.

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